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(54) APPARATUS FOR BURNING WASTE PARTICULATE MATTER

(57) A vertical or horizontal combustion assembly includes a base cylindrical portion having a plurality of pipes for injecting combustion air tangentially into the interior space, a loading port (46) in the wall of the base section and a burner (70) for igniting injected waste matter. Downstream of the base section is a ceramic choke (54) which has an axial opening of lesser diameter than the internal diameter of the base section, followed by an afterburning chamber (51), which has a plurality of air inlet pipes tangential to the chamber, and a burner port (70) for igniting vapors. Combustion air is controlled so that less than stoichiometric air is injected into the lower chamber to provide a reducing atmosphere, with excess combustion air in the afterburning section. The outlet of the afterburning chamber goes to a waste heat boiler (14) to a stack (66). A perforated sparger is immersed in the molten polymer material (38) which forms on the base of the base portion. Air or steam is provided to form turbulence in the molten material to break up the ash on the surface to increase combustion.

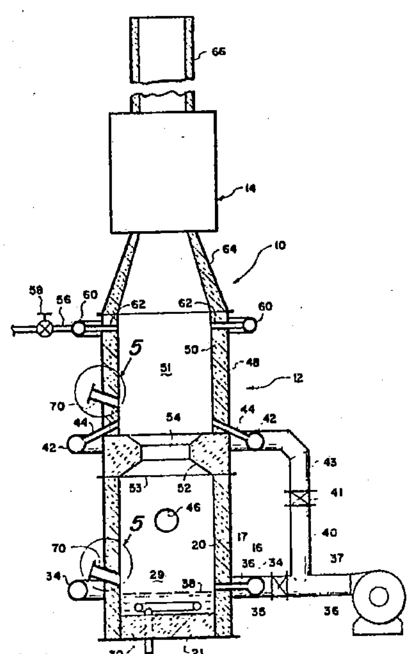

Fig.1

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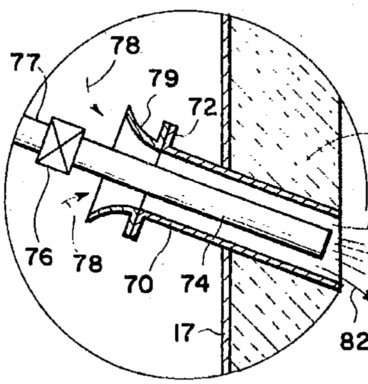

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Fig. 5

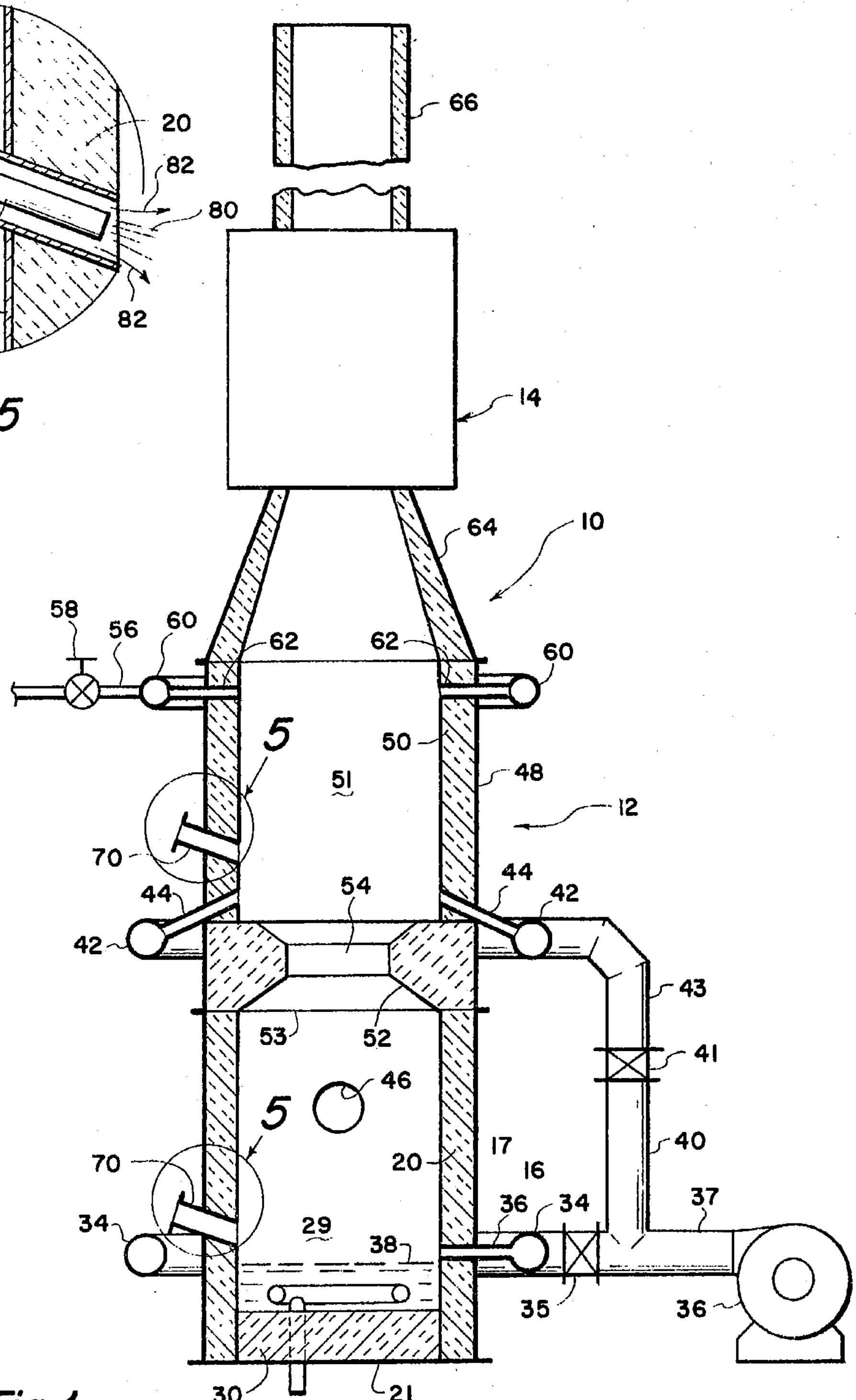

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Fig. 1

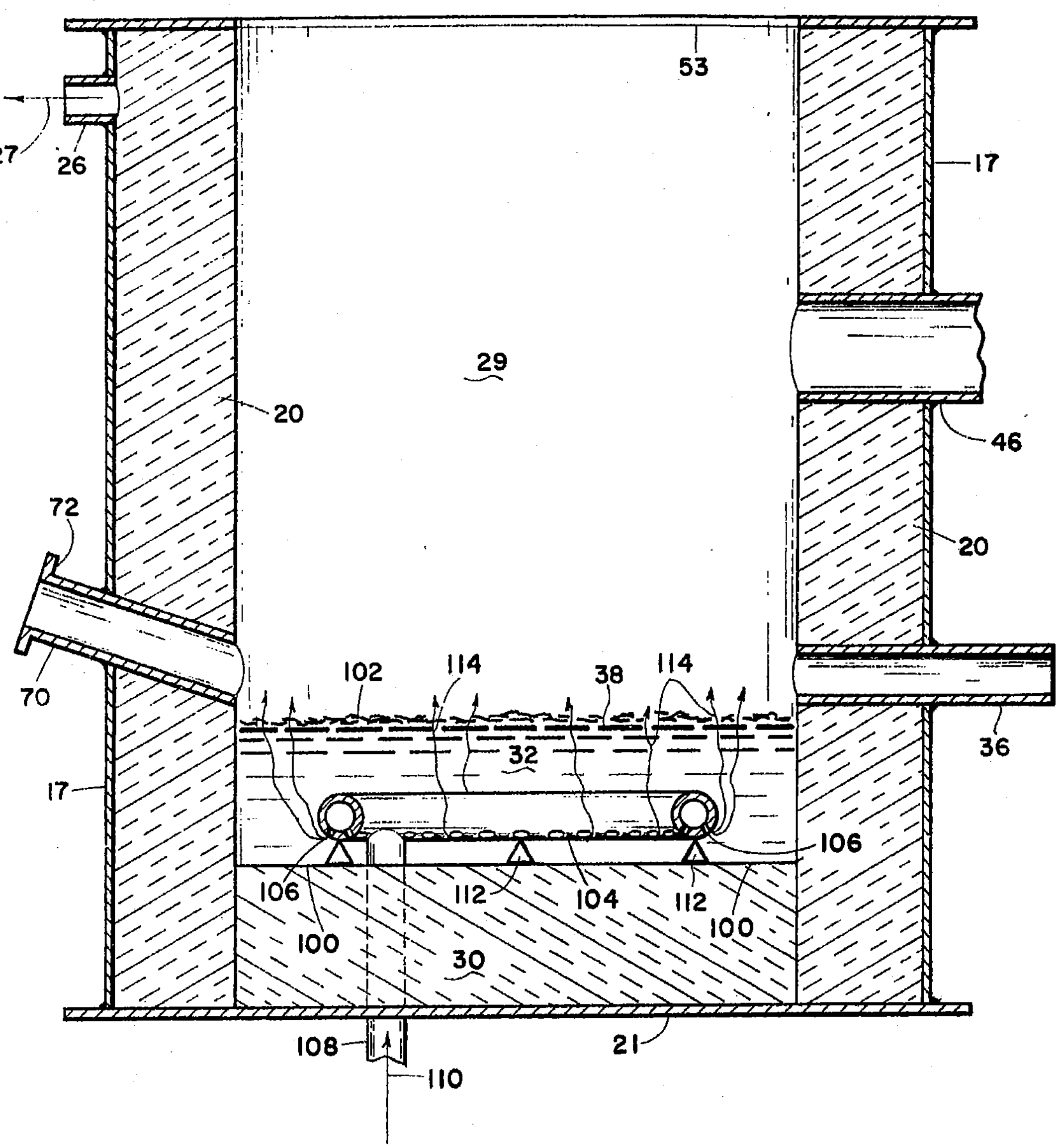
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Fig. 2

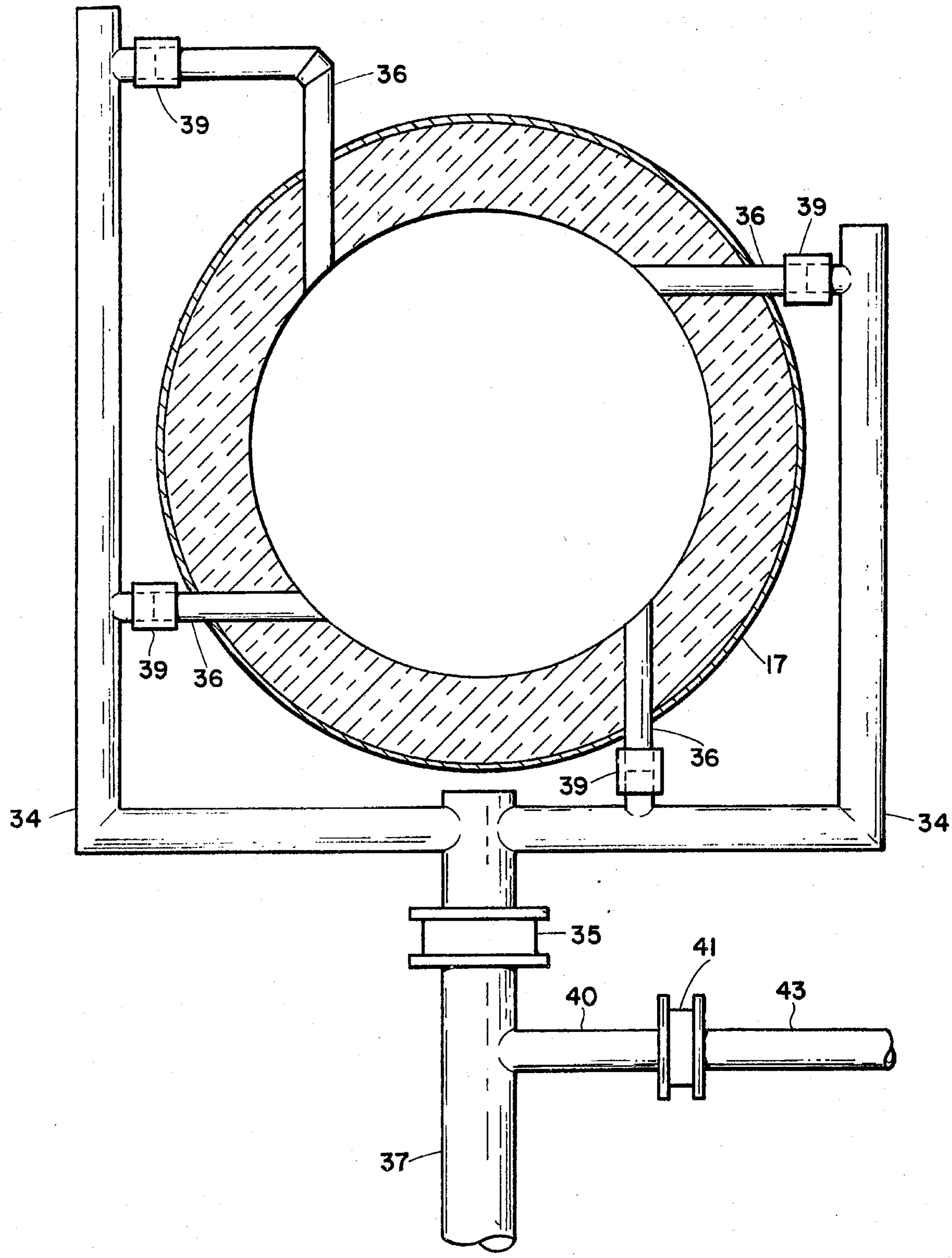

Fig. 3

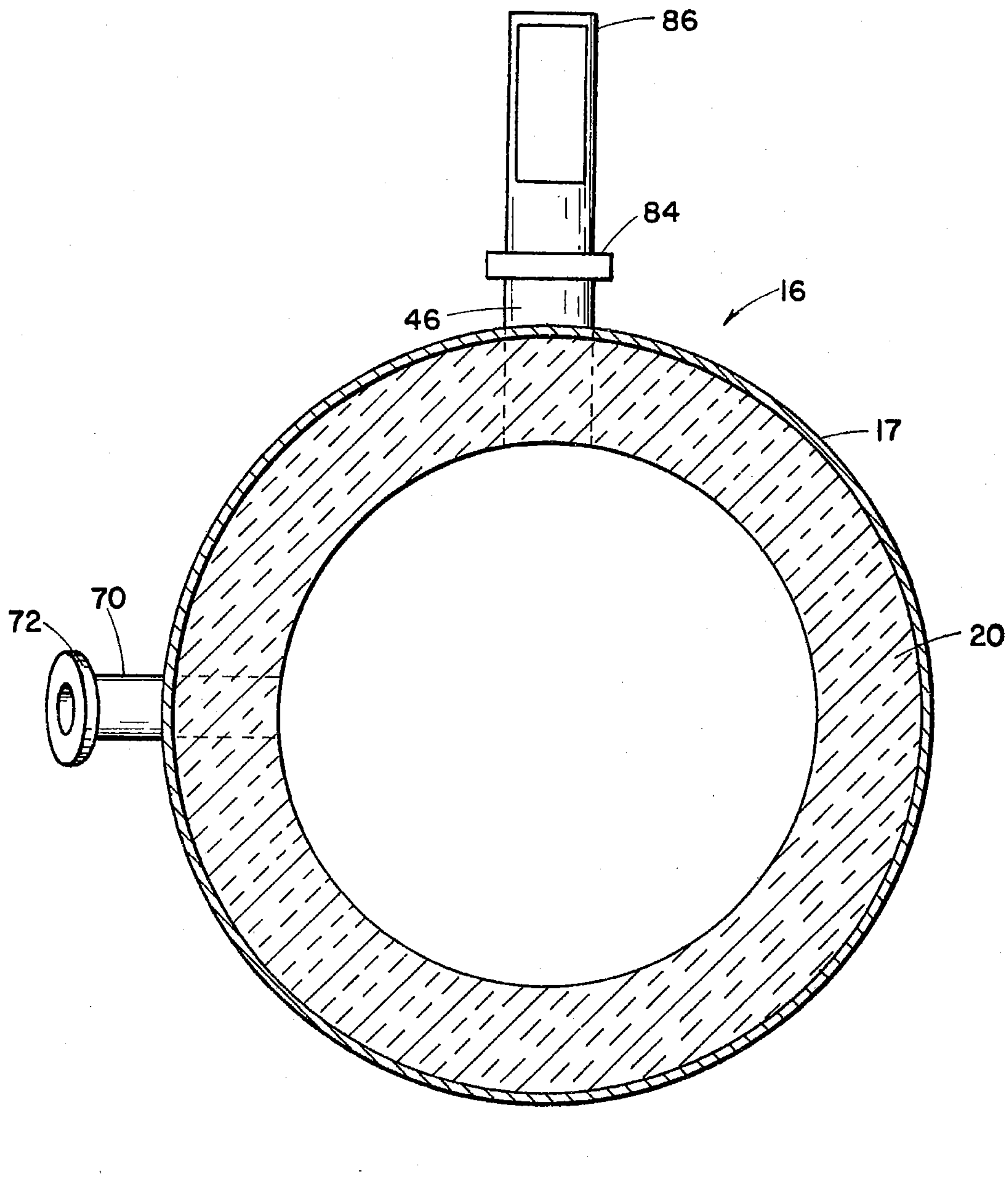

Fig. 4

SPECIFICATION

APPARATUS TO BURN SOLID POLYMERS

This invention lies in the field of the combustion of waste solid and semi-solid materials.

More particularly, this invention lies in the field of combustion of waste polymer material such as polyethylene, plastics, rubber compounds, semi-solid sludges and other combustible materials such as atactic polypropylene, for which this method is well adapted.

All plastics manufacturing processes produce some off-specification product, and some produce by-products for which no adequate market has been developed.

Historically the off-spec material that could not be "blended off," and the by-product material that could not be sold has been disposed of by land filling. This is not only expensive but, more and more, is being prohibited by environmental authorities.

The combination of environmental problems and rising fuel costs has made combustion of these waste plastics for steam generation a very attractive proposition. The technology involved, however, is not simple, and, for some plastics, only recently has become available.

Most plastics have in common the property that they cannot readily be liquified and atomized for burning in suspension. Nor is it generally practical to shred the solid into a fine, air-conveyable form for suspension burning.

The most practical method seems to be that of "hearth-burning," wherein the plastic — in any form — is introduced onto the floor of a furnace, whereupon it burns at a rate proportional to the exposed surface area. The problem here is controlling the combustion rate — frequently in the face of batchwise and erratic feedrates.

If the plastic contains considerable ash — as some atactic polypropylene does — the combustion process is further complicated by potential bliding of the surface of the molten polymer by an ash layer which seriously retards combustion rate.

Depending upon the constituents of the ash, it can also be a potential refractory slagging agent, and can certainly cause fouling of the waste heat boiler. In any event it must eventually be removed from the flue gas.

Some plastics, upon combustion, produce acid components — such as HCl and P_2O_5 in the flue gas; and these can pose serious corrosion problems in the downstream components. Obviously PVC produces HCl, but perhaps not so obviously, some atactic polypolylene may produce both HCl and P_2O_5.

In the prior art, there have been large quantities of waste plastic materials that must be disposed of, and these have been burned in conventional incinerators, with considerable difficulty. Many problems arise because of incomplete combustion, and resulting pollution of the atmosphere with smoke and toxic chemicals. Other problems arise out of excessive temperatures in the combustion apparatus, etc.

It is, therefore, a primary object of this invention to provide a combustion system whereby selected solid materials, such as polymers, that will melt at a selected temperature, can be burned under conditions of controlled temperature and complete combustion, with utilization of the heat of combustion.

It is a further object of this invention to provide a system in which the solid material is melted and vaporized in a first section, under reducing conditions, to provide products of combustion which flow into an afterburner section, where the gases are completely burned with excess air, under controlled temperature conditions, so as to inhibit the production of nitrogen oxides.

It is a further object of this invention to provide a combustion system for polymer waste material, in which the solid material is melted, forming a liquid pool, which burns at the surface under reducing conditions, to provide products of combustion which rise to an afterburner chamber, where the products of combustion are completely burned in the presence of excess air.

These and other objects are realized and the limitations of the prior art are overcome in this invention by providing a cylindrical apparatus having three tandem sections, a base section including port means for loading the waste matter into the lower chamber. A burner or other means is provided for igniting the solid material. The partial burning of the solid material provides an operating temperature such that the material melts and forms a liquid pool on the base of the chamber. Combustion air is injected into the chamber through a plurality of pipes, under pressure, for the partial combustion of the material under reducing conditions. A circular perforated sparger is immersed in the molten plastic material, and is supplied with steam or air under pressure, which flows through the perforations and creates a turbulence in the molten material, to break up the layer of ash on the surface of the molten material and increase combustion.

The gaseous products of combustion pass through a ceramic choke at the top of the base section into an afterburner section mounted on top of the choke. Here a burner provides means for ignition of the combustible vapors rising through the choke, and excess combustion air is provided, under pressure, through a plurality of pipes, tangential to the afterburner chamber, providing a means for longer residence time and turbulent mixing, so as to completely burn all of the combustible components of the waste material.

As a means for maintaining a limiting temperature in the afterburner chamber, steam, water particles, water vapor, air or inert gases may be injected under control, so as to dilute and cool the products of combustion before they leave the chamber. The products of combustion then pass through a waste heat boiler to recover part of the heat of combustion, and to the stack.

These and other objects and advantages of the

invention and a better understanding of the principles and details of the invention will be evident from the following description taken in conjunction with the appended drawings in which:

FIGURE 1 is a vertical cross-section of the apparatus of this invention.

FIGURE 2 is an enlarged detail view of the lower, or reducing chamber.

FIGURE 3 is a detail of the lower chamber showing the system for introducing combustion air.

FIGURE 4 is a detail of the lower chamber illustrating the port for entry of solid material, and the burner.

FIGURE 5 illustrates the construction of the burner as applied to the lower reduction chamber and to the afterburning chamber.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in the various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

The overall reactions associated with plastics combustion in the primary stage are illustrated below (using polypropylene as an example):

$$\text{Solid } [C_3H_6]_n + \text{heat} \rightarrow \text{liquid } [C_3H_6]_n \quad (1)$$

$$\text{Liquid } [C_3H_6] + \text{heat} \rightarrow C_3H_6 + \text{other gases} \quad (2)$$

$$C_3H_6 + O_2 \rightarrow CO_2 + H_2O + \text{heat} \quad (3)$$

$$C_3H_6 + \left\{\begin{matrix} CO_2 \\ H_2O \end{matrix}\right. + \text{heat} \rightarrow CO + H_2 \quad (4)$$

$$CO + H_2 + O_2 \rightarrow CO_2 + H_2O + \text{heat} \quad (5)$$

Even though the plastic may be introduced as a solid the rate-limiting step seems to be the pyrolysis reaction (2) which is basically a heat transfer problem.

The rate of heat transfer to the molten plastic is proportional to the temperature, the surface area, and the turbulence. Surface area is not readily controlled — especially when the plastic is introduced as solid chunks in a batchwise manner. As one might expect, the best way to control combustion rate is to use a two-stage system. In the first stage the polymer undergoes partial combustion, pyrolysis, and reforming in a sub-stoichiometric environment. Rate is controlled by regulating the combustion air rate.

The pyrolysis gases are then burned in a second stage under excess air conditions to the complete destruction of all combustible matter.

In this process a high degree of turbulence is maintained in the pyrolysis zone — not only to enhance pyrolysis rate but also to disturb any ash layer that may tend to blind the polymer surface. In fact, a key feature of our process is that such a high degree of turbulence is maintained that all the ash is entrained into the pyrolysis gases and carried out of the reactor so that mechanical ash removal methods are unnecessary. This also permits the process to be as continuous as the polymer feeding system.

This turbulent environment is achieved by proper design and placement of the primary air injection nozzles, and in some cases by recycling combustion gases from downstream of the waste heat boiler. This is further facilitated by a perforated sparger which is installed in the bottom of the base section and immersed in the molten plastic material. Steam or air under pressure is supplied to the sparger to promote this turbulence. Of course, removal of the ash opens the surface of the molten material to contact with air to promote combustion.

Theoretically, the pyrolysis section may be operated at any temperature from say 1200° F. to over 2000° F. This is related to the amount of air admitted to the unit per ft^2 of hearth area. The higher the temperature, of course, the more plastic is consumed per ft^2 of hearth area.

The thing that dictates the upper practical limit is the ash fusion temperature. If the ash softens and becomes tacky it tends to conglomerate and becomes nearly impossible to entrain away from the pyrolyzing plastic.

It turns out that very satisfactory pyrolysis rates of 30—50 lbs/hr ft^2 can be readily achieved at temperatures in the 1200—1600° F. range — where it is possible to avoid ash fusion in nearly all cases.

It is worth noting that an added advantage to operating this first stage under "reducing" conditions is that with melamine type resins the formation of NO_x can be minimized.

Along with normal flue gas components the pyrolysis gases from the primary chamber may contain various hydrocarbon fragments, CO, H_2, coke, ash, HCl, and compounds of phosphorous or sulfur.

Complete oxidation of all combustibles is achieved by injecting secondary air in such a way to achieve rapid and thorough mixing, and then providing sufficient resident time for all reactions to proceed to "equilibrium." Normally this reaction is carried out at about 25% excess air.

If no provision is made for cooling, the temperature in the oxidation chamber can be in excess of 3000° F. To operate at such temperatures is to invite refractory problems.

Furthermore, it is desirable to exhaust the gases from the oxidation furnace directly into a waste heat boiler for steam generation.

Once again the problem of ash fusion enters the picture. One cannot operate a boiler on flue gas containing fused ash. The ash will freeze onto the tubes as a "glass" that cannot be removed by soot blowing. The "glass" will accumulate until the boiler is totally inoperable.

It is imperative, therefore, that the gases entering the boiler be at such a temperature that the ash is solidified and friable. Fortunately, in many cases this can be as high as 2000—2200° F. In

a few rare cases it may be as low as 1300—1500°F.

For this reason the temperature in the afterburner section is controlled so as to avoid ash fusion. This may be done in many ways — such as water injection, high excess air rates, or cool gas recycle. Recycling cool gases from downstream of the boiler is by far the preferred method because this maximizes heat recovery.

Even with solidified ash the boiler design must be quite specialized in many cases. To accommodate soot blowers the conventional approach is to use a watertube boiler. If the ash is erosive velocities should be limited to about 50—60 ft/sec. Fins can be used but spacing should be limited to about 2 fins/inch.

If acidic components such as HCl or P_2O_5 are present serious consideration must be given to metal temperatures throughout the boiler. Dew point must be avoided. While this is not too difficult to do with HCl, it can be next to impossible if there is a sufficient amount of P_2O_5. On the other hand metal temperatures should not be too high either. HCl can be somewhat corrosive to carbon steel at temperatures much above 600°F.

Flue gas clean-up may involve particulate removal and/or absorption. Particulate removal may be accomplished with cyclones, venturis, ESP's, bag filters, etc. A typical particle size is listed in Table I. The particles are quite coarse compared to what one finds from suspension burning processes.

As a result cyclones can be quite effective in removing the bulk of the particulate. Some types of atactic polypropylene, however, may contain up to 15% ash. At these high dust loadings it is often not possible to meet today's stringent emission requirement with cyclones alone.

In these cases, however, it may still be advisable to use a hot cyclone *upstream* of the waste heat boiler to reduce fouling and soot blowing requirements, then "polish-off" the particulate in a high efficiency device on the backend of the system.

If the plastic contains chlorine, a packed absorber can be provided after the waste heat boiler to absorb the HCl and produce an HCl product of up to 20% concentration for disposal or possible reuse.

Referring now to the drawings and in particular to FIGURE 1, there is shown in vertical cross-section a view of the complete assembly 10 of this invention. The invention includes three basic parts, plus a waste heat boiler and a stack as needed. A lower combustion chamber or base portion 16 has a reducing atmosphere, into which the solid material is injected through port 46, with combustion air of less than stoichiometric quantity; an intermediate section 52 which is a ceramic choke having a reduced central opening for passage of products of combustion from the lower chamber; and on top of the choke a third section 12 where gases produced in the reducing atmosphere of the lower chamber are completely burned with excess air.

Numeral 16 illustrates generally the lower, or base section, or reducing chamber. Numeral 12 indicates generally the upper, or afterburning chamber. Numeral 14 indicates the waste heat boiler and 66 the stack, where the products of combustion are ejected into the atmosphere. The base section or lower chamber 16 comprises a vertical cylindrical chamber, having a base 21, outer wall 17, and a top flange 53 for attachment to the choke portion.

There is a ceramic base 30 in the chamber. Solid material is injected into the internal space 29 through a port 46, which will be described further in connection with FIGURES 2 and 4.

This system is adapted for the combustion of waste materials which melt at a selected temperature, such as polymer materials, such as polyethylene, polyropylene and thermoplastic materials in general. The temperature that is maintained in the lower chamber is such as to melt these materials, which form a liquid pool 30 having a surface 38.

A port 70 is provided in the wall of the lower chamber into which a burner is inserted, so as to provide a means for igniting the solid material, and providing burning at the surface 38 of the liquid pool 32. Details of the burner will be described in relation to FIGURE 5.

A plurality of tangential pipes 36, as will be described in connection with FIGURES 3, are inserted through the wall of the lower chamber at a point above the surface 38 of the molten material. There is a manifold 34 surrounding the lower chamber 16 connecting these pipes 36 through a damper 35, and pipe 37 to a compressor, blower or other source 36 of air under pressure. By means of the damper 35, the rate of flow of combustion air into the space 29 is controlled so as to maintain a reducing atmosphere. That is, the amount of air is less than that required for complete combustion of the elements in the material being burned. By use of a reduced volume of combustion air, the products of combustion generated in the lower chamber are still combustible, and will move upwardly into the afterburning or upper chamber 12.

The purpose of the choke 52, which because of the high temperature, is made of ceramic material, is to provide an opening 54 of reduced cross-section, so that the gases in the space 29 will be restrained from passing upwardly through the opening 54.

The upper chamber 12 extends up from the choke, and can be a part of, or a separate attachment to the choke 52. The upper chamber 12 comprises an outer wall 48 with thermal insulation 50 over the inner surface.

Near the bottom of the upper, or afterburning chamber, are a plurality of air inlet pipes 44 similar to those 36 in the lower chamber, but which are tilted upwardly and tangentially, to cause a swirling helical motion of the gases in the upper section, to provide intimate mixing and longer residence time, and therefore more complete combustion. A manifold 42 is provided to carry the air to the pipes 44.

As shown in FIGURE 1, the manifold 42 is connected by pipe 43 and a secondary air damper 41, and pipe 40, to the air supply 36. The damper 41 is used to provide excess air for combustion inside the afterburning chamber 51, so that all products of combustion are completely burned before they pass upward through section 64 to the stack 66.

In order to maintain a selected maximum temperature in the upper chamber, a plurality of pipes 62 are provided through the wall of the upper chamber near its top. These are connected to a steam manifold 60 which is provided with steam through valve 58 and pipe 56, in a conventional manner. Instead of steam, water particles or vapor, air or inert gases, or recirculation of cool stack gases may be used.

As in the case of the base chamber 16, a burner port 70 is provided, indicated generally by the numeral 5 and detailed in FIGURE 5.

Reference is now made to FIGURE 2 which shows in greater detail the construction of the lower or base chamber, of the apparatus of this invention. It comprises a base plate 21 carrying a cylindrical outer wall 17 welded to the base and to a top flange 53. The wall 17 is protected by thermal insulation 20. Numeral 36 indicates the plurality of air pipes which are positioned above the top of the ceramic material 30, which covers the base of the lower chamber. The tangential position of the air pipes will be discussed in connection with FIGURE 3.

A burner port 70 with connection flange 72 is provided so that a burner flame can be directed inwardly, downwardly, to the surface 38 of liquid material 32, which will be formed on top of the base ceramic 30.

Resting on the top 100 of the ceramic base 30, is a circular, perforated sparger 104, which may have legs 112. The circular pipe 104 has a plurality of openings 106 on the lower surface of the pipe. The entire assembly is adapted to be fully submerged in the molten plastic 32, and so out of the flame above the surface 38.

Ash 102 forms and rests on the surface 38. This is a disadvantage since it covers part of the surface, and limits contact of the molten material with the combustion air supplied through pipes 36.

Air or steam under pressure is supplied to the sparger through supply pipe 108 in accordance with arrow 110. This flows out of the perforations 106 and bubbles up through the molten material in accordance with arrows or lines 114, causing rolling and boiling of the liquid. The turbulence breaks the surface, freeing the ash which is blown up and free of the surface, leaving more of the surface exposed and facilitating the combustion.

Of course, if air is the gas supplied to the sparger, it becomes part of the combustion air. Thus the air supplied through pipes 36 must be reduced, so that the total air is the same as that supplied by pipes 36 when steam or inert gas is supplied to the sparger.

Referring to FIGURE 3, there is a manifold 34 which surrounds the base section outside of the outer wall 17. There are a plurality of pipes 36 which can be in any desired number but which, for convenience, are shown as 4, which are supplied with air under pressure from the manifold 34.

Indicated by numeral 39 is a flexible coupling, such as a rubber hose, which may be used between the pipes 36 leads from the manifold 34. As mentioned previously, and shown in FIGURE 1 there is a damper 35 for control of the flow rate of air to the lower chamber from pipe 37 from the air compressor or blower 36 of FIGURE 1.

There is a vertical pipe 40 (shown horizontal for convenience) which goes to a second damper 41 and pipe 43 to the plurality of air pipes 44 passing through the wall of the upper chamber shown in FIGURE 1. The manifold and pipes will be similar to that shown in FIGURE 3, except that the pipes 44 are tilted upwardly.

Referring now to FIGURE 4, there is shown a cross-section of the lower chamber taken at the plane 4—4 of FIGURE 1. This shows the inner and outer wall 17 and 18, and the burner port 70 with flange 72.

The port 46 as shown, has an opening through the wall, end has an air seal 84, and a loading means such as a fluid eductor, plunger ram, or loading feed screw, allows waste polymer material to be injected into the chamber. The loading apparatus 84 and 96 is conventional in every respect. No further detail is required, other than to point out that there is excess pressure above atmospheric, in the lower chamber, so that means must be provided for preventing the escape of hot products of combustion out through the port 46. This is part of the conventional design, indicated generally by the numeral 86.

Ports 70 have been shown in both the lower chamber 16 and the upper chamber 12 for the ignition of the solid and liquid material in the lower chamber, and ignition of the gaseous material in the upper chamber, which passes up through the choke opening 54. One embodiment of the burner is shown in FIGURE 5. This comprises a burner tube 74 which is supported axially inside of the port 70 by means not illustrated, but well known in the art. Gas is supplied to the burner through a valve 76 and pipe 78. There is a conventional orifice in the end of the burner tube 74, which provides a long jet 80 of gas issuing at high velocity from the end of the burner tube 74. The high velocity of the gas jet 80 causes the induction of combustion air through the annulus between the burner tube 74 and the port wall 70 in the form of air flow indicated by arrows 78, through a flared portion 79 of the port, through the annular space, and into the interior 29 of chamber 16 in accordance with arrows 82, so that the jet of gas is mixed with the air 82 and burned. The flame that ignites the gas 80 is provided by conventional means and need not be further described.

As an example of the economics of this system, the following is provided for a system designed to burn 1000 lbs/hr of atactic polypropylene containing 8—10% ash. In this particular case, no

acidic components are present in the flue gas.

The net heating value of the plastic is about 19,500 BTU/lb, so the total heat release in the system is about 17.9×10^6 BTU/hr. The system generates 15,800 lbs/hr of saturated 600 psig steam from 220°F. boiler feedwater. This represents a thermal efficiency of almost 90%.

The economics of the system should be about as follows:

A.	Major Equipment Cost (Includes all vessels, shop installed refractory, ductwork, fans, controls, ladders, platforms, structural, etc. — but excluding plastic feeding and ash removal facilities)	$600,000
B.	Installation Cost (Includes site preparation, foundations, erection, piping, field wiring, etc.)	$600,000
C.	Total Investment	$1,200,000
D.	Income (8600 hrs/hr)	
	Steam value at $3.00/1000 lbs	$407,640
	Savings of 2 cents/lb disposal expense	172,000
		$579,649
E.	Expenses	
	Electrical — 100 KW at 3 cents	$25,800
	Labor — 0.25 operator at $15.00/hr	32,250
	0.25 supervisor at $50,000/yr	12,500
	Depreciation at 10%	120,000
	Maintenance at 3%	36,000
	Miscellaneous	20,000
	Total	$246,555
F.	Earnings $579,640 — $246,555 =	$333,085
G.	Gross Return on Investment	28%

Obviously, this is a very rough economic analysis, but it should be accurate enough to illustrate that burning waste plastic for steam generation can be a very attractive proposition — especially if environmental authorities permit no alternative.

TABLE I.

Typical Particle Distribution of Ash Generated in Hearth Burning of Plastic

Particle Size, microns	% by wt.
850 +	0.86
420 — 850	4.17
250 — 420	10.54
150 — 250	27.82
75 — 150	39.45
37 — 75	8.0
19 — 37	4.0
10 — 19	2.0
10 and less	3.2

What has been described is a three-part structure for the loading of solid particulate matter, ground into chunks of sizes suitable for burning, through a loading port, into a lower combustion chamber where it is ignited by a burner. A selected combustion temperature is maintained in the lower combustion chamber, sufficient to melt the loaded material to form a liquid pool at the bottom of the chamber, so that the material will burn at its surface 38. The combustion of the liquid 32 is facilitated by air which is introduced under pressure through a plurality of tangential pipes 36 to provide turbulence and mixing of the gases rising from the surface 38.

Air or steam injected below the surface of the molten material, causes a turbulence of the surface of the molten material, which breaks up a layer of ash, which rises with the flame, uncovering the molten surface and promoting combustion.

Less than stoichiometric air is provided, so that there will be a reducing atmosphere in the space 29, and combustible gaseous products will pass up through a choke 52 into the afterburning chamber 12. Here a burner is provided to ignite the gases, and a plurality of tangential air pipes 44 are provided. Means are provided to control the air flow so as to provide a less than stoichiometric quantity in the lower chamber, and an excess of air in the upper chamber, so as to completely burn all of the combustible material. The tangential flow of

air into both chambers serves to facilitate the mixing and combustion of the gases. In addition, steam flow is provided into the upper chamber, as necessary, to maintain a limited maximum temperature.

CLAIMS

1. Apparatus for burning waste particulate matter, comprising:

(a) a cylindrical base portion, including:
   (1) a cylindrical wall lined with refractory material;
   (2) means to inject solid particulate material of selected thermal and combustion characteristics at a port near the top of said base portion;
   (3) thermal insulating means over the base of said base portion adapted to support said particulate material in solid and liquid form;
   (4) burner means in said base section to ignite said particulate matter;
   (5) means to inject air under pressure, at a controlled rate for combustion of said particulate matter under reducing conditions, with less than stoichiometric air;

(b) an intermediate choke portion, mounted on top of said base portion, said choke of refractory material, having a central opening of smaller diameter than the diameter of said base portion;

(c) an afterburner chamber on top of said choke portion; all three portions suitably fastened and sealed together and including:
   (1) said afterburner chamber lined with refractory;
   (2) means to inject excess combustion air under pressure, to completely burn the products of combustion formed in the partial combustion in said base portion; and

(d) waste heat boiler means;

(e) stack means to conduct to the atmosphere the products of combustion in said afterburner chamber; and including

(f) circular, perforated sparger means on top of said thermal insulating means in said base portion, adapted to be totally immersed in the molten material which will lie on the top of said thermal insulating means; and including

(g) means to supply a selected gas under pressure to said sparger means at a selected flow rate;

whereby the turbulence provided by said flow of gas causes the layer of ash which forms on the surface of said molten material to be broken up, and to flow to the stack, thereby uncovering more of the surface of said molten material and promoting the rate of combustion thereof.

2. The apparatus as in claim 1 including burner means in said afterburner chamber to ignite said gases formed in said base portion.

3. The apparatus as in claim 1 including means to controllably inject steam into said afterburner chamber to control the temperature therein.

4. The apparatus as in claim 1 in which said means to inject air under pressure comprises a plurality of pipes through the wall of said base portion directed tangential to the interior volume of said base portion.

5. The apparatus as in claim 1 in which said means to inject air under pressure comprises a plurality of pipes through the wall of said afterburner chamber near the base thereof.

6. The apparatus as in claim 1 in which said particulate matter includes materials which melt at a temperature below burning temperature and form a liquid pool on the bottom of said base portion.

7. The apparatus as in claim 6 in which said waste particulate material comprises solid polymers.

8. The apparatus as in claim 7 in which polymers are in the class of polyethylene, atactic polypropylene and thermoplastic rubbers.

9. The apparatus as in claim 1 in which said selected gas supplied to said sparger means comprises at least steam.

10. The apparatus as in claim 1 in which said selected gas supplied to said sparger comprises at least air.

11. The apparatus as in claim 1 in which said selected gas supplied to said sparger comprises a mixture of steam and air.

12. The apparatus as in claim 10 in which the total flow of air to said sparger means and to said base portion for combustion of said particulate matter, under reducing conditions, is a constant.

13. The apparatus as in claim 1 including means to controllably inject recycled cooled stack gases into said after burner chamber to control the temperature therein.

14. Apparatus for burning waste polymeric material, comprising:

(a) a cylindrical base portion, including:
   (1) a cylindrical chamber lined with refractory material;
   (2) means to inject polymeric material of selected thermal and combustion characteristics at a port above the bottom of said chamber;
   (3) thermal insulating means over the bottom of said chamber adapted to support said polymeric material;
   (4) burner means in said base section to ignite said material;
   (5) means to inject air under pressure, at a controlled rate for combustion of said material under reducing conditions, with less than stoichiometric air;

(b) refractory lined afterburner chamber above said base portion and suitably fastened and sealed together and including:
   (1) means to inject additional combustion air under pressure, to completely burn the products of combustion formed

from the partial combustion in said cylindrical chamber;

(c) stack means to conduct to the atmosphere the products of combustion in said after-burner chamber;

(d) a perforated sparger means on top of said thermal insulating means in said cylindrical chamber, adapted to be totally immersed in molten polymeric material which will lie on the top of said thermal insulating means; and

(e) means to supply a selected fluid under pressure to said sparger means at a selected flow rate;

whereby the turbulence provided by said flow of gas causes the layer of ash which forms on the surface of said molten material to be broken up, and to flow to the stack, thereby uncovering more of the surface of said molten material and promoting the rate of combustion thereof.

15. Apparatus for burning waste particulate matter constructed and arranged to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

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